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(54) 3D MAMMOGRAPHY

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to 3D mammography, in which individual images of a breast are taken at different projection angles, typically within an angle of about +/- 30 degrees from the vertical, and in which a 3D image is subsequently synthesized from this image information by an applicable image processing software.

DESCRIPTION OF PRIOR ART

[0002] Breast cancer is the most common type of cancer in women. According to investigations, about one in every ten women contract breast cancer at some point in their lives. When breast cancer is detected on the basis of symptoms, the illness often has already developed to a stage where the prognosis for recovery is relatively poor. Some of the cases are detected in screening programs arranged in many countries for women over the age of 40. Screening often reveals a cancer at a very early stage, so its treatment can be started in time and recovery is thus more likely.

[0003] Mammography is a widely used method in breast cancer screening as a clinical investigation method and also in follow-up diagnosis. Mammography is an X-ray imaging method wherein an apparatus specifically designed for this purpose is used. In screening studies, mammography has been reported to have a sensitivity of 90 - 93 % and a specificity of 90 - 97 %. This indicates that screening studies are useful and that early detection of breast cancer by screening can save human lives. It has been established that mammography reduces breast cancer mortality by 35 percent among women over 50 and by 25 - 35 percent among women at the age of 40 - 50 years.

[0004] The mammography images are examined to detect various anomalies in the breast, such as calcifications, i.e. small deposits of calcium in the soft breast tissue. A calcification generally cannot be detected by feeling the breast, but it is visible in the x-ray image. Large calcifications are generally not associated with cancer, but clusters of small calcium deposits, i.e. so-called micro-calcifications, are an indication of extra breast cell activity, which may be associated with breast cancer. Other features to be detected by mammography include cysts and fi-broadenomas, which, however, are generally not associated with cancer.

[0005] In conventional screening mammography, typically the breast gland is compressed between two compression plates and exposed to radiation at least twice, from above and from an oblique direction. If necessary, additionally a third image is taken squarely from the side. As in such imaging, the tissue layers lie on top of each other in the direction of the x-ray beam, these irradiations produce two-dimensional images in which strongly absorbing structures may hinder the detection of structures lying beneath them.

[0006] Continual improvement in the mammography has led to novel type of mammography methods and devices that produce a 3D image of the patient's breast. Here, several projections of the breast at different angles are produced and a 3D distribution of it is created by using an applicable reconstruction algorithm. From the image information, i.e. the individual images, typically several images are constructed which represent layers of the breast oriented in parallel with the surface of the x-ray detector, thus making possible to detect tissue structures laying on top of each other.

[0007] A typical digital mammography apparatus comprises a frame part and a C-arm or a corresponding structure rotatably connected to the frame part. At the first end of the C-arm, there is arranged an x-ray source and at the second end, a radiation detector. A term imaging means is often used for these devices. Disposed substantially in the region between said x-ray source and detector, typically at close proximity to the detector, compression plates are arranged which are designed for positioning the breast as compressed for the duration of the exposure.

[0008] In prior art, in the context of 3D mammography, various ways to image the breast at a number of different projection angles have been used or suggested. These include continuously turning the x-ray source, with a constant or an alternating speed, along a curved path about the breast, turning the x-ray source step by step between exposures during which the x-ray source remains still, and using multiple stationary x-ray sources. As for the detector, it may be kept stationary, moved linearly and/or tilted such that it remains at right angles to the center ray of the x-ray beam for each exposure.

[0009] US patent application publication 2004/0101096 A1 discloses a mammography apparatus wherein the compression plates are either shifted as the x-ray source is rotated, or the compression plates are tilted while the x-ray source is kept stationary.

[0010] Ren et al., Proceedings of the SPIE vol. 5745 pp. 550-561, describes a mammography system which can either be used in conventional mammography or tomosynthesis mode. In conventional mammography, the compression plates may rotate with the x-ray source, but no images are acquired while this rotation takes place, whereas in tomosynthesis mode, the compression plates are kept stationary as the x-ray source rotates.

[0011] The x-ray source, located at the (upper) end of the C-arm, is a relatively heavy component. In the case of step-by-step movement of the x-ray source, prior to each exposure the imaging apparatus should have reached a vibration free status. Thus, the structures of the mammography apparatus should be optimized in view of the number of accelerations, decelerations and stops (stabilization times) comprised in the multi-phase imaging procedure. The overall time needed for an imaging procedure like this tends to become quite long.

[0012] On the other hand, in the case of continuous movement of the x-ray source, remarkably short exposure times, such as less than 50 ms, must be used in order to avoid creating movement artefacts. This in turn calls for using a powerful enough radiation source, which means using an even heavier x-ray source than those typically used in prior art 2D mammography apparatus and, consequently, other constructions of the imaging apparatus must be designed in view of this greater mass as well.

[0013] As for arranging several x-ray sources in a mammography apparatus, this obviously calls for a completely new type of design for a mammography apparatus in order to make it possible to implement such a specific 3D imaging modality. With this kind of a mechanical design as a basis, it would be a challenge to be able to come up with a construction that would make the apparatus practical for use in conventional 2D screening mammography as well.

SUMMARY OF THE INVENTION

[0014] The object of the current invention is focused on eliminating or reducing at least some of the problems of the imaging systems discussed above. The object of the invention is reached by the method and apparatus of the independent claims 1 and 10 attached hereto. Some preferable embodiments of the invention are presented in the attached dependent claims.

[0015] The invention makes 3D mammography possible with the existing type of mammography apparatus, i.e. with the same kind of x-ray sources and C-arm and related construction as are typically used, by enabling the use of substantially long exposure times even though continuously moving the x-ray source during the imaging procedure. This is made possible by arranging for the breast to follow the movement of the x-ray source during at least one exposure phase of the imaging procedure. As the tomographic angle (the angle between the extreme exposure positions of the x-ray source) used in the imaging process may be of several tens of degrees, to make turning of the breast during a number of exposures possible in practise, a preferable embodiment of the procedural cycle of the invention includes a step of turning the breast back to its previous/initial position during a (each) non-exposure period of the imaging process.

[0016] One of the basic advantages of the invention is that constructing such a means in a mammography apparatus which enables repeated turning and stopping of the breast (i.e. turning and stopping of the breast holding means, such as the compression plates) during the imaging procedure is considerably simpler than arranging a corresponding movement procedure for the radiation source. In the invention, as far as the radiation source as such and the constructions for moving the radiation source are concerned, there is no need for any specific arrangements or fundamental re-design of the apparatus but the conventional design used in prior art 2D mammography may be made use of.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] In the following, some embodiments of the invention and their benefits will be described in more detail, also with help of the attached figures, of which figures

- figure 1 represents a construction of a typical mammography apparatus,
- figures 2a and 2b represent movements of an x-ray source of a mammography apparatus according to prior art methods to acquire image information for 3D mammography,
- figures 3a and 3b represent movements of certain constructions of a mammography apparatus according to the invention, and
- figure 4 represents a C-arm of a mammography apparatus fitted with an arrangement for drawing tissue into the volume between compression plates of the apparatus.

DETAILED DESCRIPTION OF THE INVENTION

[0018] A typical mammography apparatus 1 as presented in figure 1 consists of a body part 11 and a C-arm construction 12 connected to it. Typically, a radiation source 13 and an image data receiving means 15, arranged e.g. inside a so-called lower shelf structure 14, are placed at the opposite ends of the C-arm 12. These depicting means 13, 15, being located inside the cover of the apparatus, are actually not visible in figure 1.

[0019] Further, within the area between the depicting means 13, 15, typically in the proximity of the image data receiving means 15, a means 16, 17 for positioning/locking the object to be imaged within the imaging area has been placed. Nowadays, typically, this kind of an apparatus is motorized such that the C-arm 12 is arranged movable in a vertical direction and rotatable about an axis, typically a physical horizontal axis connecting the C-arm to the body part 11. The positioning/locking means 16, 17 typically consist of an upper compression plate 16 and a lower compression plate 17, which lower compression plate 17 may be arranged integrated with the lower shelf structure 14. Inside the lower shelf, a grid structure may be located above the image data receiving means 15, which grid structure limits entry of radiation scattered from the tissue to the image data receiving means 15. In the context of the current invention, it is in practise a necessity that the rotation axis of the C-arm 12 be arranged in such manner with respect to the location of the compression plates 16, 17 (locking means) that the patient can remain at the same position for exposures regardless of the inclination angle of the C-arm. Such a construction for this type of mammography apparatus has been taught in the European patent publication 370089.

[0020] Figures 2a and 2b represent prior art systems to acquire image information for 3D mammography. For the sake of clarity, in Figs. 2a, 2b, 3a, 3b not an actual cone-shaped x-ray beam originating from the focus of the x-ray source 13 but only the central ray is shown.

[0021] In the prior art system according to Fig. 2a, the x-ray source 13 is arranged to move in a continuous fashion from a starting position of the imaging procedure to an end position of the imaging procedure, and during this movement, the x-ray source 13 is energized for the duration of a number of short exposure periods, while the compression plates 16, 17 (and in Fig. 2a, also the detector 15) remain stationary. The image information detected at the detector 15 is stored and/or sent to image processing. In this kind of construction, use of a conventional anti-scatter grid is not possible as the grid would absorb a portion of the desired x-ray quanta as well at all the other exposure angles but that which is parallel with orientation of the grid lamella.

[0022] In the prior art system according to Fig. 2b, on the other hand, the x-ray source 13 is moved in a stepwise manner such that for each exposure, the x-ray source is stopped at a predefined angular position. In Fig. 2b, three such stationary exposure positions of the x-ray source 13 are shown.

[0023] Figures 3a and 3b show two basic operational phases of the current mammography imaging invention. Fig. 3a can be regarded as showing one exposure phase and Fig. 3b as showing one non-exposure phase of the system, together with the extreme positions of the x-ray source 13. In these Figs, these extreme positions of the x-ray source 13 with respect to the vertical indicate the width of the tomographic angle of the system, whereas in Fig. 3a the two close to vertical positions of the x-ray source 13, and the corresponding positions of the breast locking means 16, 17 and the detector 15, depict the core operational phase of the system according to the invention, and in Fig. 3b those of a certain preferable embodiment of the invention. In the embodiment of the invention shown as a whole in Figs. 3a and 3b, during an exposure phase (Fig. 3a), the compression plates 16, 17 are arranged to turn as synchronized with the movement of the x-ray source 13, while during a non-exposure phase (Fig. 3b), they are turned in the opposite direction. In this embodiment of the invention, the detector 15 is arranged to turn together with the compression plates 16, 17.

[0024] The synchronized movement of the x-ray source 13 and the compression plates 16, 17 according to the invention makes possible avoiding creating such movement artefacts that are always present when the breast is imaged according to a prior art method of Fig 2a, where there is mutual movement between the x-ray source 13 and the breast during an exposure. As compared to that method, the invention also makes possible using longer exposure times and does not necessitate using an extra-powerful and thus heavier x-ray source.

[0025] On the other hand, because of not having to stop the x-ray source 13 for the duration of an (each) exposure, the time needed for the whole imaging process will be considerably shorter than that needed for a prior art process according to Fig. 2b.

[0026] As there are a number of exposures in 3D mammography, simply repeatedly turning the compression plates 16, 17 in the direction of the movement of the x-ray source 13 during each exposure period (and keeping them still during the non-exposure periods) would add up turning the compression plates 16, 17 say 15 degrees, for example, which as far as the patient is concerned would make the imaging process uncomfortable. To avoid this, preferable embodiments of the invention include an operational phase during which the x-ray source 15 is not energized (a non-irradiation period) and the compression plates 16, 17 (and the detector 15) are turned in the direction opposite to that of the movement of the x-ray source 13. According to the preferable embodiment of the invention as shown in Fig. 3b, the compression plates 16, 17 and the detector 15 are turned back to their initial position at the beginning of the preceding irradiation period.

[0027] The angle through which the compression plates 16, 17 will be turned can be arranged to be very small and the periods of non-exposure to be longer than the exposure periods so that there will be plenty of time to establish a stable starting situation for a subsequent exposure period. In other words, according to preferable embodiments of the invention, there will be plenty of time for counter-turning the breast as the periods when the x-ray source 13 is not energized are arranged to be considerably longer than the periods during which it is energized. Thinking of an example of having a typical prior art mammography apparatus and using 12 exposures starting at intervals of 5 degrees, the compression plates 16, 17 could be turned through 2 degrees or even less, which would easily leave enough time for backwards turning even when taking into account the time needed for acceleration and deceleration of the movements.

[0028] As shown in Fig. 3a, in one preferable embodiment of the invention, both the radiation source 13 and the image detector 15 are moved at the same essentially regular angular velocity around the breast whilst it is compressed between the compression plates 16, 17 - or locked otherwise in a means arranged for this purpose.

[0029] In practise, regarding embodiments of the invention as shown in Figs. 3a and 3b, it is essential that the compression plates 16, 17, or said other locking means for the breast, are arranged to turn at a short distance from the rotation centre of the radiation source 13 for the most, since during the imaging procedure according to the invention, it would be impossible to reposition the patient for irradiations at different projection angles.

[0030] According to a specific preferable embodiment of the invention, first, during exposure of each of the projection images, the compression plates 16, 17, or said other locking means, are turned as synchronized with the movement of the radiation source 13. Thus, the breast will remain still with respect to the radiation source 13 during each such irradiation period. Then, second, between the irradiation periods, the compression plates 16, 17 are turned back to their position at the beginning of the preceding irradiation period. As a consequence, the total angle the locking means 16, 17 shall turn needs to be only as small as the angle of turn needed for creating synchronization of movements during an individual exposure of one projection image. This angle may be arranged to be e.g. less than 2 degrees, such as 0,5 - 2 degrees, which in view of the strain to a patient will be tolerable. Thus, even when taking into account the required accelerations and decelerations, as discussed, in case images are taken at 5 degree intervals, for example, over a tomographic angle of say 50 degrees, there will still be plenty of time for returning the locking means (e.g. upper and lower compression plate 16, 17) back to their initial position at the beginning of an exposure phase.

[0031] More generally speaking, in the system according to the invention, the breast to be imaged is arranged locked in a locking means 16, 17 and during the imaging process, an x-ray source 13 is moved with respect to the location of the breast to be imaged and the breast is irradiated during a number of irradiation periods which begin at a number of angular positions of the x-ray source 13. During the imaging process, the x-ray source 13 is moved continuously and the breast is irradiated during a number of short irradiation periods and, during a period when the breast is being irradiated, the locking means 16, 17 is moved as synchronized with the movement of the x-ray source 13. Regarding a mammography apparatus according to the invention, it comprises a body part 11 and arranged thereto an x-ray source 13, an image detector 15 as well as within an area between the x-ray source 13 and the image detector 15, a means arranged for locking a breast 16, 17, the x-ray source 13 being arranged movable with respect to the location of said locking means 16, 17. Further, the apparatus comprises a control system arranged to control operation of the apparatus. The locking means 16, 17 is arranged turnable and movement of the locking means 16, 17 and the x-ray source 13 is arranged motorised and the operation of the x-ray source controlled by said control system such that during an imaging process, the x-ray source 13 moves continuously and the breast is irradiated during a number of short irradiation periods and, during an irradiation period, said locking means 16, 17 turns as synchronized with the movement of the x-ray source 13.

[0032] The imaging procedure may include a phase prior to the first irradiation period wherein said locking means 16, 17 is turned in a direction opposite to that when moved as synchronized with the movement of the x-ray source 13. There may be periods of backwards movement of the locking means 16, 17 in between any number of successive irradiation periods. The length of the turning-back movement of the locking means 16, 17 (and possibly also that of the image detector 15) may be either exactly the same as during an exposure period, i.e. the locking means 16, 17 may be moved back to its initial position at the beginning of a preceding exposure period, or the backwards movement may be shorter or longer than the one having taken place during a preceding exposure. The length of the backwards movement does not have to be any exact multiple of the steps of the movement during an exposure. As an exemplary embodiment of the invention, the imaging procedure may consist of steps of two exposure periods between which the locking means 16, 17 do not turn in any direction, but after the second of these exposure periods, the backwards movement will correspond to the total movement of the locking means 16, 17 during these two exposure periods.

[0033] The extreme positions of the x-ray source 13 with respect to the breast during the imaging process may be arranged to make up a tomographic angle of several tens of degrees, such as about 50 degrees. In one preferable embodiment, the overall movement of the x-ray source 13 is arranged to be symmetrical with respect to the vertical, i.e. the overall tomographic angle to be about plus-minus 25 degrees with respect to the vertical. Preferably, the movement of the x-ray source 13 is arranged to follow a curved path as in the case of typical existing mammography apparatus, yet the principle of the invention may be realized also when moving the x-ray source linearly.

[0034] Considering the angles from another point of view, the ratio between the angle of the minute individual turns of the locking means 16, 17 during exposure periods with respect to the overall displacement of the x-ray source 13 may be arranged to be of the order of 1/10. The imaging procedure may be arranged to consist of about 11-15 exposure periods.

[0035] Even though varying breast thicknesses and the desired velocity of the x-ray source 13 may affect what is optimal, preferable embodiments of the invention include using an x-ray source 13 comprising a tungsten anode which, with proper arrangements such as using a selenium based imaging detector and especially a silver filter of proper thickness to absorb those low energy x-ray quanta which would not be able to penetrate the breast tissue, can result in a reduced radiation dose when compared to some other arrangements. In the context of preferable embodiments of the invention, exposure times for the projection images of around 50-100 ms may be used, and imaging parameter values for the x-ray tube voltage of around 35-40 kV, even up to 45 kV, and about 5 mAs. With kV values of about 30-34, mAs values of about 10-13 may be used.

[0036] One preferable embodiment of the invention includes an arrangement in which in functional connection with the locking means, there has been arranged a means for pulling tissue into the space between the compression plates 16, 17. Such a means may be arranged to comprise e.g. an arrangement as shown in Fig. 4, wherein an upper and a lower stretching device 30 are integrated with both of the compression plates 16, 17. The stretching devices 30 may be arranged to comprise a means for engaging and pulling a stretching means, such as a plastic sheet 31, so that in connection with compressing the breast between the compression plates 16, 17, breast tissue will be drawn in between the compression plates 16, 17 upon positioning of the breast for imaging. Such an arrangement enables using perhaps 10 % less compression in the context of the current invention than typically used in the art of mammography, which makes the imaging procedure including both compressing and turning a breast less awkward.

[0037] The current invention is applicable for use both in the context of so called full-field sized and smaller imaging detectors used in mammography.

Claims

1. A mammography imaging method in which a breast to be imaged is arranged locked in a locking means (16,17) within an area between an x-ray source (13) and an image detector (15) of a mammography apparatus and in which during the imaging process, the x-ray source (13) is moved with respect to location of the breast and the breast is irradiated at a number of angular positions of the x-ray souroe (13) with respect to location of the breast, **characterized in that**, during the imaging process, the x-ray source (13) is moved continuously and the breast is irradiated during a number of short irradiation periods and, during an irradiation period, said locking means (16,17) is turned as synchronized with the movement of the x-ray source (13) to follow the movement thereof.

2. The method according to claim 1, **characterized in that** prior to the first irradiation period, and/or in between any number of subsequent irradiation periods, that is during a period when the breast is not being irradiated, said locking means (16,17) is turned in a direction opposite to that when turned as synchronized with the movement of the x-ray source (13).

3. The method according to claim 1 or 2, **characterized in that** after an irradiation period during which said locking means (16, 17) is moved as synchronized with the movement of the x-ray source (13) and prior to at least one subsequent irradiation period, said locking means (16,17) is turned at least substantially back to its initial position, i.e. at least substantially to its position at the beginning of said preceding irradiation period, or **in that** the imaging process includes a number of irradiation periods during which said locking means (16, 17) is turned as synchronized with the movement of the x-ray source (13), and during each non-irradiation period subsequent to such irradiation periods, the locking means (16,17) is turned at least substantially back to its position at the beginning of such preceding irradiation period.

4. The method according to any of the daims 1 - 3, **characterized in that** the movement of the locking means (16, 17) during an irradiation period includes turning the locking means (16,17) for an angle through 2 degrees or less, such as through 0,5 - 2 degrees.

5. The method according to any of the claims 1 - 4, **characterized in that** the extreme angular positions of the x-ray source (13) with respect to the breast during the imaging process make up a tomographic angle of several tens of degrees and/or the overall movement of the x-ray source (13) is arranged to be symmetrical with respect to a vertical.

6. The method according to any of the claims 1 - 5, **characterized in that** the movement of the x-ray source (13) is arranged to follow a curved path about the breast.

7. The method according to any of the claims 1 - 6, **characterized in that** the locking means (16,17) comprises compression plates (16,17) between which a breast is compressed for the duration of the imaging process, and/or a stretching means (30, 31) is arranged to be used for drawing breast tissue in between the locking means (16,17) / the compression plates (16,17).

8. The method acoording to any of the claims 1-7, **characterized in that** during an irradiation period, the x-ray source (13) is operated depending on the breast tissue characteristics by using imaging parameter values for the x-ray tube including a tungsten anode of about 35 - 45 kV and about 5 mAs, or about 30 - 34 kV and 10 -13 mAs.

9. The method according to any of the claims 1 - 8, **characterized in that** the method includes about 11-15 irradiation periods and/or a ratio between the angle through which the locking means (16,17) is turned during an irradiation period and the total tomographic angle of the imaging process is less than 1/10.

10. A mammography apparatus comprising a body part (11) and arranged thereto an x-ray source (13), an image detector (15) as well as within an area between the x-ray source (13) and the image detector (15), a means arranged for locking a breast (16,17), the x-ray source (13) being arranged movable with respect to location of said locking means (16,17), the apparatus further comprising a control system arranged to control operation of the apparatus, **characterized in that** said breast locking means (16,17) is arranged turnable and movement of the locking means (16,17) and the x-ray source (13) is arranged motorised and operation of the x-ray source control-

led by said control system such that during an imaging process, the x-ray source (13) moves continuously and the breast is irradiated during a number of short irradiation periods and, during an irradiation period, said locking means (16,17) turns as synchronized with the movement of the x-ray source (13) to follow the movement thereof.

11. The mammography apparatus according to claim 10, **characterized in that** the control system is arranged to control operation of the apparatus such that prior to the first irradiation period, and/or in between any number of subsequent irradiation periods, that is during a period when the breast is not being irradiated, said locking means (16,17) turns in a direction opposite to that when turning as synchronized with the movement of the x-ray source (13).

12. The mammography apparatus according to claim 10 or 11, **characterized in that** the control system is arranged to control operation of the apparatus i) such that after an irradiation period during which said locking means (16,17) is moved as synchronized with the movement of the x-ray source 13 and prior to at least one subsequent irradiation period, said locking means (16,17) turns at least substantially back to its initial position, i.e. at least substantially to its position at the beginning of said preceding irradiation period, or ii) such that there are a number of irradiation periods during which said locking means (16,17) turns as synchronized with the movement of the x-ray source (13), and during each of the non-irradiation periods subsequent to such irradiation periods, the locking means (16,17) turns at least substantially back to its position at the beginning of such preceding irradiation period.

13. The mammography apparatus according to any of the claims 10 -12, **characterized in that** the control system is arranged to control operation of the apparatus such that the locking means (16,17) turns during an irradiation period through an angle of 2 degrees or less, such as through 0,5 - 2 degrees.

14. The mammography apparatus according to any of the claims 10 -13, **characterized in that** the movement of the x-ray source (13) is arranged to follow a curved path about a breast positioned in the breast locking means (16,17).

15. The mammography apparatus according to any of the claims 10 -14, **characterized in that** the locking means (16,17) comprises compression plates (16,17) between which a breast is compressed for the duration of the imaging process and/or a stretching means (30, 31) has been arranged to the apparatus for pulling breast tissue in between the locking means (16,17) / the compression plates (16,17).

Patentansprüche

1. Mammographieabbildungsverfahren, bei dem eine Brust, die abgebildet werden soll, derart angeordnet ist, dass sie in einem Verriegelungsmittel (16,17) eingeschlossen ist innerhalb eines Bereichs zwischen einer Röntgenquelle (13) und einem Bilddetektor (15) einer Mammographievorrichtung
wobei während des Abbildungsprozesses, die Röntgenquelle (13), in Bezug auf die Lage der Brust bewegt wird und die Brust aus einer Anzahl von Winkelstellungen der Röntgenquelle (13) in Bezug auf die Lage der Brust bestrahlt wird,
dadurch gekennzeichnet, dass
sich während des Abbildungsprozesses die Röntgenquelle (13) fortlaufend bewegt und während einer Anzahl von kurzen Bestrahlungszeiträumen die Brust bestrahlt wird und,
während eines Bestrahlungszeitraumes das Verriegelungsmittel (16,17) abgestimmt auf die Bewegung der Röntgenquelle (13) gedreht wird, um die Bewegung derer zu verfolgen.

2. Verfahren nach Anspruch 1 **dadurch gekennzeichnet, dass**
vor dem ersten Bestrahlungszeitraum und/oder zwischen irgendwelchen nachfolgenden Bestrahlungszeiträumen, d.h. während einer Periode, wenn die Brust nicht bestrahlt wird, die Verriegelungseinrichtung (16,17) in einer Richtung gedreht wird, entgegengesetzt zu jener in die sie gedreht wird in Synchronisation mit der Bewegung der Röntgenquelle (13).

3. Verfahren nach Anspruch 1 oder 2 **dadurch gekennzeichnet, dass**
nach einem Bestrahlungszeitraum, während dessen die Bewegung des Verriegelungsmittels (16,17) synchron mit der Bewegung der Röntgenquelle (13) ist und vor zumindest einem nachfolgendem Bestrahlungszeitraum, das Verriegelungsmittel (16,17) zumindest im wesentlichen wieder in seine Anfangsposition gedreht wird, das heißt zumindest im wesentlichen in die Anfangsposition des vorangehenden Bestrahlungszeitraums, oder
dass der Abbildungsprozess eine Anzahl von Bestrahlungszeiträumen beinhaltet, während denen sich das Verriegelungsmittel (16,17) synchron zu den Bewegungen der Röntgenquelle (13) dreht, und während jedem nicht Bestrahlungszeitraum, anschließend an einen Bestrahlungszustand das Verriegelungsmittel (16,17) zumindest im wesentlichen zurück in die Anfangsposition eines solchen Bestrahlungszeitraums gedreht wird.

4. Verfahren nach einem der Ansprüche 1 bis 3 **dadurch gekennzeichnet, dass**
die Bewegung der Verriegelungseinrichtung (16,17)

während einem Bestrahlungszeitraum die Bewegung des Verriegelungsmittels (16,17) um einen Winkel über 2 Grad oder weniger, wie zum Beispiel 0,5 bis 2 Grad, umfasst.

5. Verfahren nach einem der Ansprüche 1 bis 4 **dadurch gekennzeichnet, dass**
extreme Winkelstellungen der Röntgenquelle (13) im Bezug auf die Brust während des Abbildungsprozesses einen tomographischen Winkel von einigen zehn Grad bilden und/oder die Gesamtbewegung der Röntgenquelle (13) symmetrisch in Bezug zur Vertikalen eingerichtet ist.

6. Verfahren nach einem der Ansprüche 1 bis 5 **dadurch gekennzeichnet, dass**
die Bewegung der Röntgenquelle (13) so eingerichtet ist, dass sie einem gekrümmten Pfad über die Brust folgt.

7. Verfahren nach einem der Ansprüche 1 bis 6 **dadurch gekennzeichnet, dass**
das Verriegelungsmittel (16,17) Druckplatten (16,17), zwischen denen die Brust für die Dauer des Abbildungsprozesses zusammengedrückt wird, aufweist, und/oder Streckmittel (30,31), geeignet, um Brustgewebe zwischen den Verriegelungsmitteln (16,17)/Druckplatten (16,17) zu ziehen.

8. Verfahren nach einem der Ansprüche 1 bis 7 **dadurch gekennzeichnet, dass**
während eines Bestrahlungszeitraumes die Röntgenquelle (13) abhängig von den Eigenschaften des Brustgewebes unter Verwendung der Bildparameterwerte für die Röntgenquelle betrieben wird, die eine Wolframanode von etwa 35 - 45 kV und 5 mAs oder etwa 30 bis 34 kV und 10 - 13 mAs beinhaltet.

9. Verfahren nach einem der Ansprüche 1 bis 8 **dadurch gekennzeichnet, dass**
das Verfahren ungefähr 11-15 Bestrahlungszeiträume umfasst und/oder
das Verhältnis zwischen dem Winkel, um den die Verriegelungsmittel (16,17) sich während einem Bestrahlungszeitraum bewegen, und den gesamt tomographischen Winkel des Abbildungsprozesses kleiner als 1 zu 10 ist.

10. Mammographievorrichtung mit einem Körperteil (11) und einer daran angeordneten Röntgenquelle (13), einen Bilddetektor (15) sowie in einem Raum zwischen der Röntgenquelle (13) und dem Bilddetektor (15) ein Mittel, angeordnet zum Verriegeln der Brust (16,17), wobei die Röntgenquell (13) beweglich im Bezug zur Lage des Verriegelungsmittels (16,17) angeordnet ist, wobei die Vorrichtung ferner ein Steuersystem hat, angeordnet zum Steuern der Vorrichtung
dadurch gekennzeichnet, dass
das Brustverriegelungsmittel (16,17) drehbar gelagert ist und die Bewegung des Verriegelungsmittels (16, 17) und der Röntgenquelle (13) motorisiert eingerichtet ist und der Betrieb der Röntgenquelle durch ein Steuersystem gesteuert wird, so dass sich die Röntgenquelle (13) während eines Bestrahlungsprozesses kontinuierlich bewegt und die Brust während einer Anzahl kurzer Bestrahlungszeiträume bestrahlt wird, wobei
während eines Bestrahlungszeitraumes sich das Verriegelungsmittel synchron mit der Bewegung der Röntgenquelle (13) dreht, um der Bewegung dieser zu folgen.

11. Mammographievorrichtung nach Anspruch 10 **dadurch gekennzeichnet, dass**
das Steuersystem eingerichtet ist, um den Betrieb der Vorrichtung zu steuern, so dass vor dem ersten Bestrahlungszeitraum und/oder zwischen irgendwelchen nachfolgenden Bestrahlungszeiträumen, d.h. während einer Periode, wenn die Brust nicht bestrahlt wird, das Verriegelungsmittel (16,17), in einer Richtung entgegengesetzt zu der wenn es synchron mit der Bewegung der Röntgenquelle (13) ist, dreht.

12. Mammographievorrichtung nach Anspruch 10 oder 11 **dadurch gekennzeichnet, dass**
das Steuersystem eingerichtet ist, um den Betrieb der Vorrichtung zu steuern

i) so dass sich nach einem Bestrahlungszeitraum, während dessen das Verriegelungsmittel (16,17) synchron zur Bewegung der Röntgenquelle bewegt wird und vor mindestens einem nachfolgenden Bestrahlungszeitraum, das Verriegelungsmittel zumindest im Wesentlichen zurück in die Anfangsposition dreht, das heißt, zumindest im Wesentlichen in die Position zu Anfang des vorhergehenden Bestrahlungszeitraums oder
ii) so dass eine Anzahl von Bestrahlungszeiträumen, während welchen das Verriegelungsmittel (16, 17) sich synchron zur Bewegung der Röntgenquelle (13) dreht, und während jedem nicht Bestrahlungszeitraum im Anschluss an einen solchen Bestrahlungszeitraum, sich das Verriegelungsmittel (16,17) zumindest im Wesentlichen zurück in die Anfangsposition des vorhergehenden Bestrahlungszeitraums dreht.

13. Mammographievorrichtung nach einem der Ansprüche 10 bis 12 **dadurch gekennzeichnet, dass**
das Steuersystem eingerichtet ist, um den Betrieb der Vorrichtung zu steuern, so dass das Verriegelungsmittel (16,17) sich während eines Bestrahlungszeitraums um einen Winkel von 2 Grad oder weniger, wie zum Beispiel über 0,5 bis2 Grad, dreht.

14. Mammographievorrichtung nach einem der Ansprüche 10 bis 13 **dadurch gekennzeichnet, dass** die Bewegung der Röntgenquelle (13) so eingerichtet ist, dass sie einem gekrümmten Pfad über die Brust, positioniert im Brustverriegelungsmittel (16,17), folgt.

15. Mammographievorrichtung nach einem der Ansprüche 10 bis 13 **dadurch gekennzeichnet, dass** das Verriegelungsmittel (16,17) Druckplatten (16,17), zwischen denen die Brust für die Dauer des Abbildungsprozesses zusammengedrückt wird, aufweist, und/oder Streckmittel (30,31) an der Vorrichtung zum Ziehen des Brustgewebes zwischen den Verriegelungsmitteln(16, 17)/Druckplatten (16,17) eingerichtet wurden.

Revendications

1. Procédé d'imagerie pour mammographie dans lequel un sein à radiographier est placé bloqué dans un moyen de blocage (16, 17) dans une zone entre une source de rayons X (13) et un détecteur d'image (15) d'un appareil de mammographie et dans lequel, pendant le processus d'imagerie, la source de rayons X (13) est déplacée par rapport à l'emplacement du sein et le sein est irradié sur un nombre de positions angulaires de la source de rayons X (13) par rapport à l'emplacement du sein, **caractérisé en ce que**, pendant le processus d'imagerie, la source de rayons X (13) est déplacée continuellement et le sein est irradié durant un nombre de courtes périodes d'irradiation et durant une période d'irradiation, ledit moyen de blocage (16, 17) tourne en étant synchronisé avec le mouvement de la source de rayons X (13) pour suivre le mouvement de celle-ci.

2. Procédé selon la revendication 1, **caractérisé en ce que**, avant la première période d'irradiation et/ou entre un nombre de périodes d'irradiations consécutives c'est-à-dire durant une période pendant laquelle le sein n'est pas irradié, ledit moyen de blocage (16, 17) tourne dans une direction opposée à celle pendant laquelle il tourne en étant synchronisé avec le mouvement de la source de rayons X (13).

3. Procédé selon la revendication 1 ou 2, **caractérisé en ce que**, après une période d'irradiation durant laquelle ledit moyen de blocage (16, 17) est déplacé en étant synchronisé avec le mouvement de la source de rayons X (13) et avant au moins une période d'irradiation consécutive, ledit moyen de blocage (16, 17) retourne au moins substantiellement à sa position initiale, c'est-à-dire au moins substantiellement à sa position au début de ladite période d'irradiation précédente, ou **en ce que** le procédé d'imagerie comprend un certain nombre de périodes d'irradiation durant lesquelles ledit moyen de blocage (16, 17) tourne en étant synchronisé avec le mouvement de la source de rayons X (13) et durant chaque période de non irradiation consécutive à ces périodes d'irradiation, le moyen de blocage (16, 17) retourne au moins substantiellement à sa position au début de cette période d'irradiation précédente.

4. Procédé selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** le mouvement du moyen de blocage (16, 17) durant une période d'irradiation comprend la rotation du moyen de blocage (16, 17) sur un angle de 2 degrés ou inférieur, tel que de 0,5 à 2 degrés.

5. Procédé selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** les positions angulaires extrêmes de la source de rayons X (13) par rapport au sein pendant le procédé d'imagerie constituent un angle tomographique de plusieurs dixièmes de degrés et/ou le mouvement global de la source de rayons X (13) est conçu de façon à être symétrique par rapport à un axe vertical.

6. Procédé selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** le mouvement de la source de rayons X (13) est conçu pour suivre une trajectoire courbe autour du sein.

7. Procédé selon l'une quelconque des revendications 1 à 6, **caractérisé en ce que** le moyen de blocage (16, 17) comprend des plaques de compression (16, 17) entre lesquelles un sein est comprimé pendant la durée du processus d'imagerie et/ou un moyen d'étirement (30, 31) est conçu pour être utilisé pour tirer un tissu mammaire entre le moyen de blocage (16, 17)/ les plaques de compression (16, 17).

8. Procédé selon l'une quelconque des revendications 1 à 7, **caractérisé en ce que**, durant une période d'irradiation, la source de rayons X (13) est actionnée en fonction des caractéristiques du tissu mammaire en utilisant des valeurs de paramètres d'imagerie du tube de rayons X comprenant une anode au tungstène d'environ 35 à 45 kV et d'environ 5 mAs ou d'environ 30 à 34 kV et 10 à 13 mAs.

9. Procédé selon l'une quelconque des revendications 1 à 8, **caractérisé en ce que** le procédé comprend environ 11 à 15 périodes d'irradiation et/ou un rapport entre l'angle selon lequel le moyen de blocage (16, 17) tourne durant une période d'irradiation et l'angle tomographique total du procédé d'imagerie est inférieur à 1/10.

10. Appareil de mammographie comprenant une partie de corps (11) et disposés sur celui-ci, une source de rayons X (13), un détecteur d'image (15) ainsi que, dans une zone entre la source de rayons X (13) et le détecteur d'images (15), un moyen conçu pour bloquer un sein (16, 17), la source de rayons X (13) étant conçue de façon à pouvoir être mobile par rapport à l'emplacement dudit moyen de blocage (16, 17), l'appareil comprenant en outre un système de commande conçu pour commander le fonctionnement de l'appareil, **caractérisé en ce que** ledit moyen de blocage du sein (16, 17) est conçu de façon à pouvoir tourner et un mouvement du moyen de blocage (16, 17) et la source de rayons X (13) est conçue motorisée et le fonctionnement de la source de rayons X est commandé par ledit système de commande de sorte que, pendant un processus d'imagerie, la source de rayons X (13) se déplace continuellement et le sein est irradié durant un nombre de courtes périodes d'irradiation et durant une période d'irradiation, ledit moyen de blocage (16, 17) tourne en étant synchronisé avec le mouvement de la source de rayons X (13) pour suivre le mouvement de celle-ci.

11. Appareil de mammographie selon la revendication 10, **caractérisé en ce que** le système de commande est conçu pour commander le fonctionnement de l'appareil, de telle sorte que, pendant la première période d'irradiation et/ou entre un nombre quelconque de périodes d'irradiation consécutives c'est-à-dire durant une période pendant laquelle le sein n'est pas irradié, ledit moyen de blocage (16, 17) tourne dans une direction opposée à celle pendant laquelle il tourne en étant synchronisé avec le mouvement de la source de rayons X (13).

12. Appareil de mammographie selon la revendication 10 ou 11, **caractérisé en ce que** le système de commande est conçu pour commander le fonctionnement de l'appareil i) de sorte que, après une période d'irradiation durant laquelle ledit moyen de blocage (16, 17) est déplacé en étant synchronisé avec le mouvement de la source de rayons X 13 et avant au moins un période d'irradiation consécutive, ledit moyen de blocage (16, 17) retourne au moins substantiellement à sa position initiale c'est-à-dire au moins substantiellement à sa position au début de ladite période d'irradiation précédente ou ii) de sorte qu'il existe un nombre de périodes d'irradiation durant lesquelles ledit moyen de blocage (16, 17) tourne en étant synchronisé avec le mouvement de la source de rayons X (13) et durant chacune des périodes de non irradiation, consécutive à ces périodes d'irradiation, le moyen de blocage (16, 17) retourne au moins substantiellement à sa position au début de cette période d'irradiation précédente.

13. Appareil de mammographie selon l'une quelconque des revendications 10 à 12, **caractérisé en ce que** le système de commande est conçu pour commander le fonctionnement de l'appareil de sorte que le moyen de blocage (16, 17) tourne durant une période d'irradiation d'un angle de 2 degrés ou inférieur, tel que de 0,5 à 2 degrés.

14. Appareil de mammographie selon l'une quelconque des revendications 10 à 13, **caractérisé en ce que** le mouvement de la source de rayons X (13) est conçu pour suivre une trajectoire courbe autour d'un sein placé dans le moyen de blocage du sein (16, 17).

15. Appareil de mammographie selon l'une quelconque des revendications 10 à 14, **caractérisé en ce que** le moyen de blocage (16, 17) comprend des plaques de compression (16, 17) entre lesquelles un sein est comprimé pendant la durée du processus d'imagerie et/ou un moyen d'étirement (30, 31) a été disposé dans l'appareil pour tirer un tissu mammaire entre le moyen de blocage (16, 17)/ les plaques de compression (16, 17).

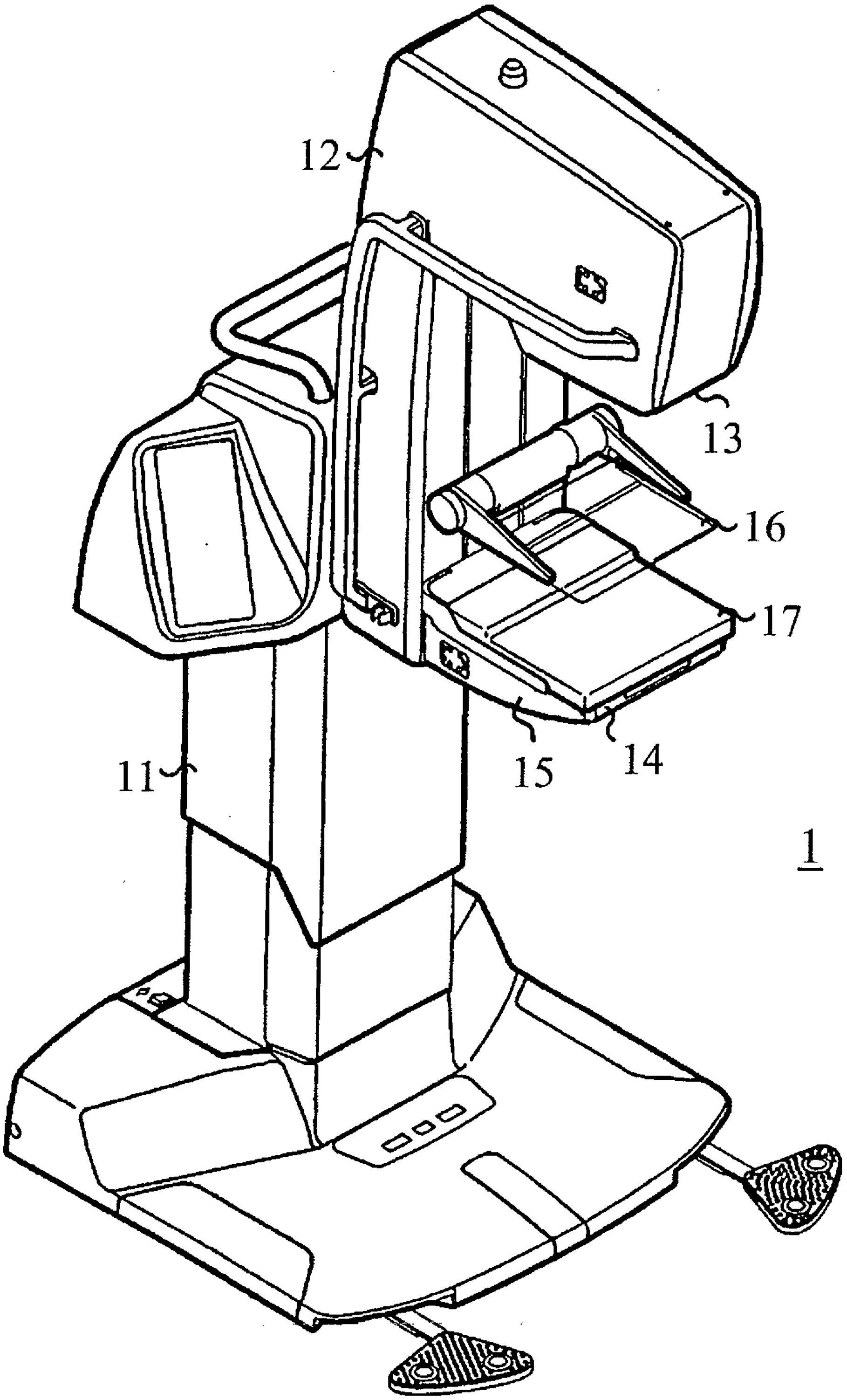
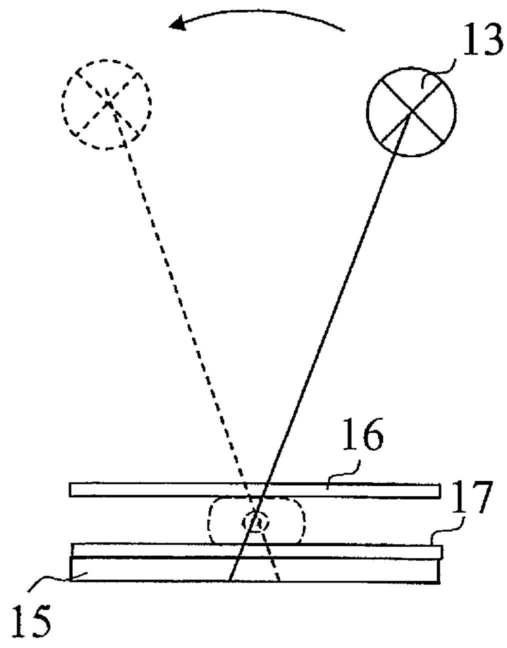
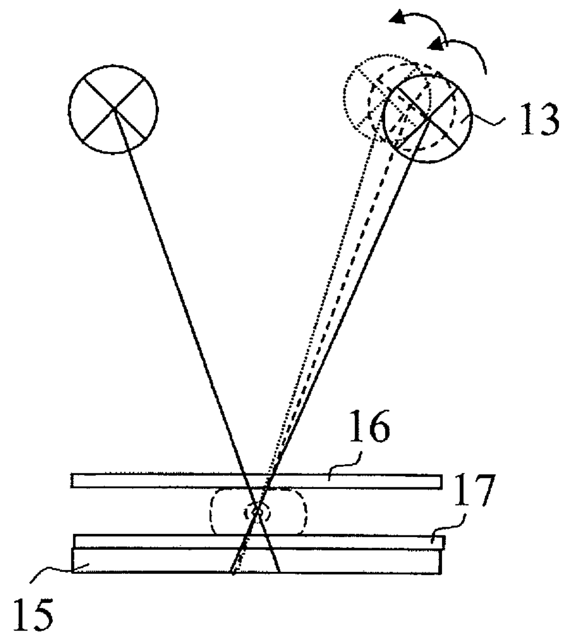


Fig. 1



prior art

Fig. 2 a



prior art

Fig. 2 b

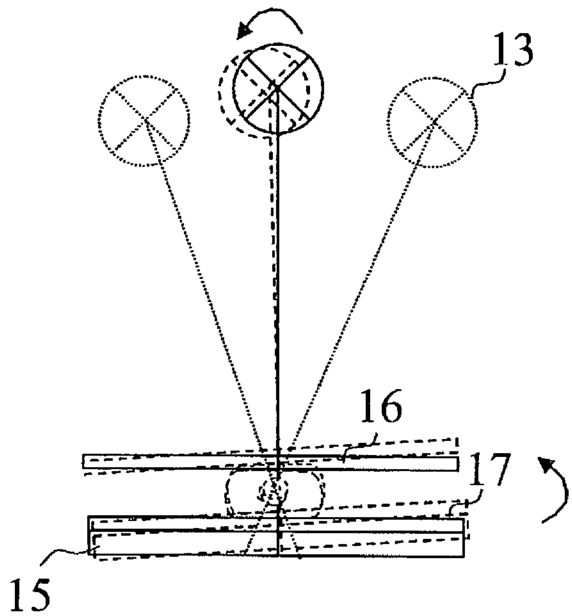


Fig. 3 a

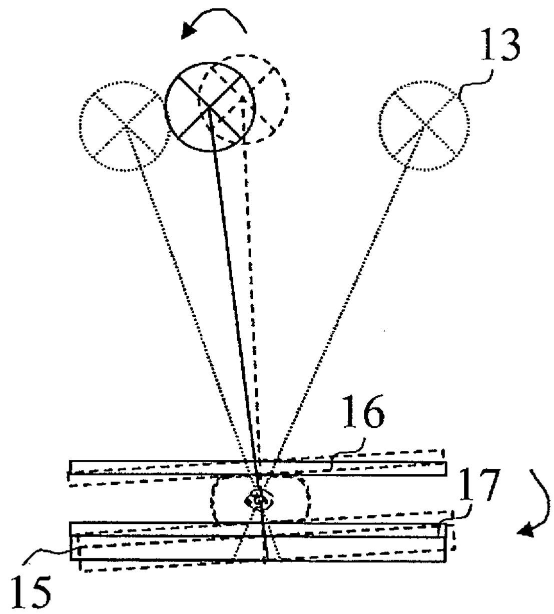


Fig. 3 b

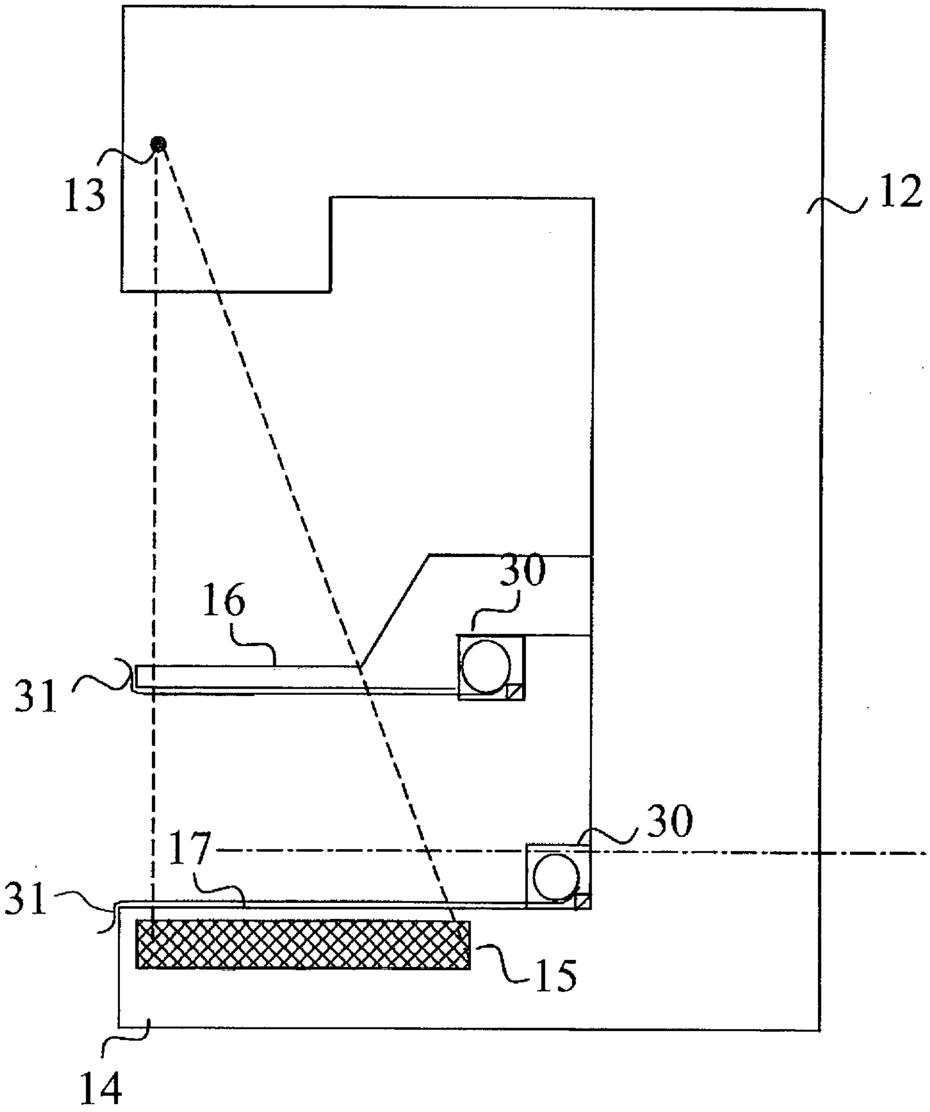


Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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